



# James Webb Space Telescope (JWST) Optical Telescope Element (OTE) Pathfinder Status and Plans

Lee Feinberg, NASA GSFC

MSFC Tech Days

Nov 18<sup>th</sup>, 2014

Contributors:

NGAS, Exelis, ATK, Ball, Sigma, Genesis, GSFC, JSC



# Pathfinder Purpose

---



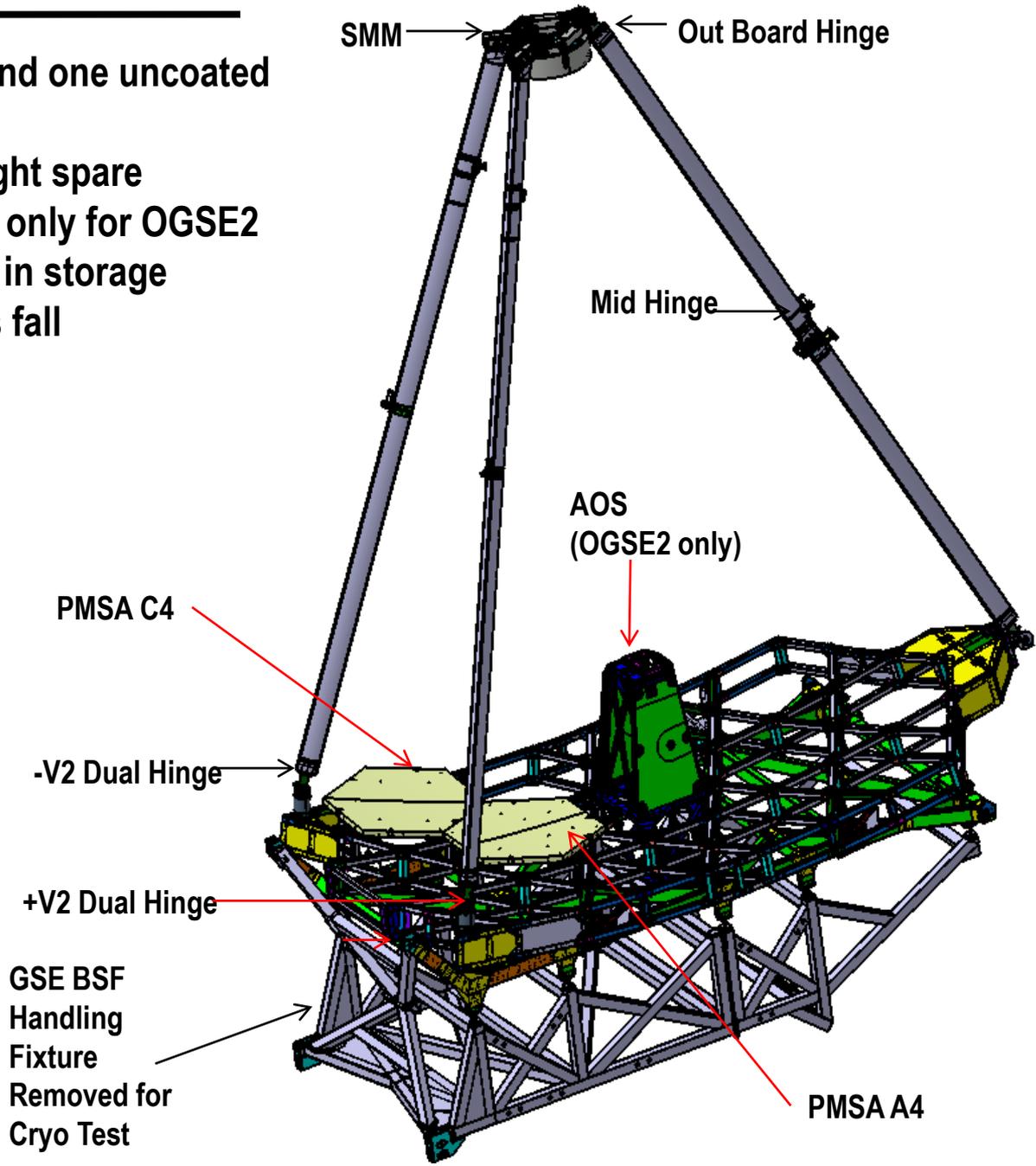
- **The JWST OTE Pathfinder is a partial telescope that is intended to reduce the implementation risk of the assembly, integration, and cryogenic optical test of the JWST optical assembly.**
- **A key goal for the OTE Pathfinder is to allow early checkout of the optical test procedures and test equipment to be used for cryogenic optical testing prior to their use in testing the flight hardware.**
- **The Pathfinder will undergo three basic cryogenic tests:**
  - **Optical Ground Support Equipment 1 (OGSE1)**
  - **Optical Ground Support Equipment 2 (OGSE2)**
  - **Thermal Pathfinder**
- **No flight verification occurs with Pathfinder**
- **The optical and thermal GSE used to test the flight OTIS (Optical Telescope Element + Integrated Science Instrument Module (ISIM)) will be checked out during the Pathfinder testing program**

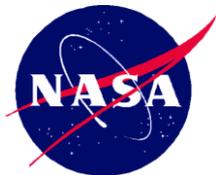


# Pathfinder Overview



- Includes one coated PMSA (A4) and one uncoated PMSA (C4), flight spares
- Secondary Mirror is uncoated, flight spare
- AOS (flight) and ASPA are added only for OGSE2
- All flight optics are complete and in storage
- AOS will be tested with ASPA this fall



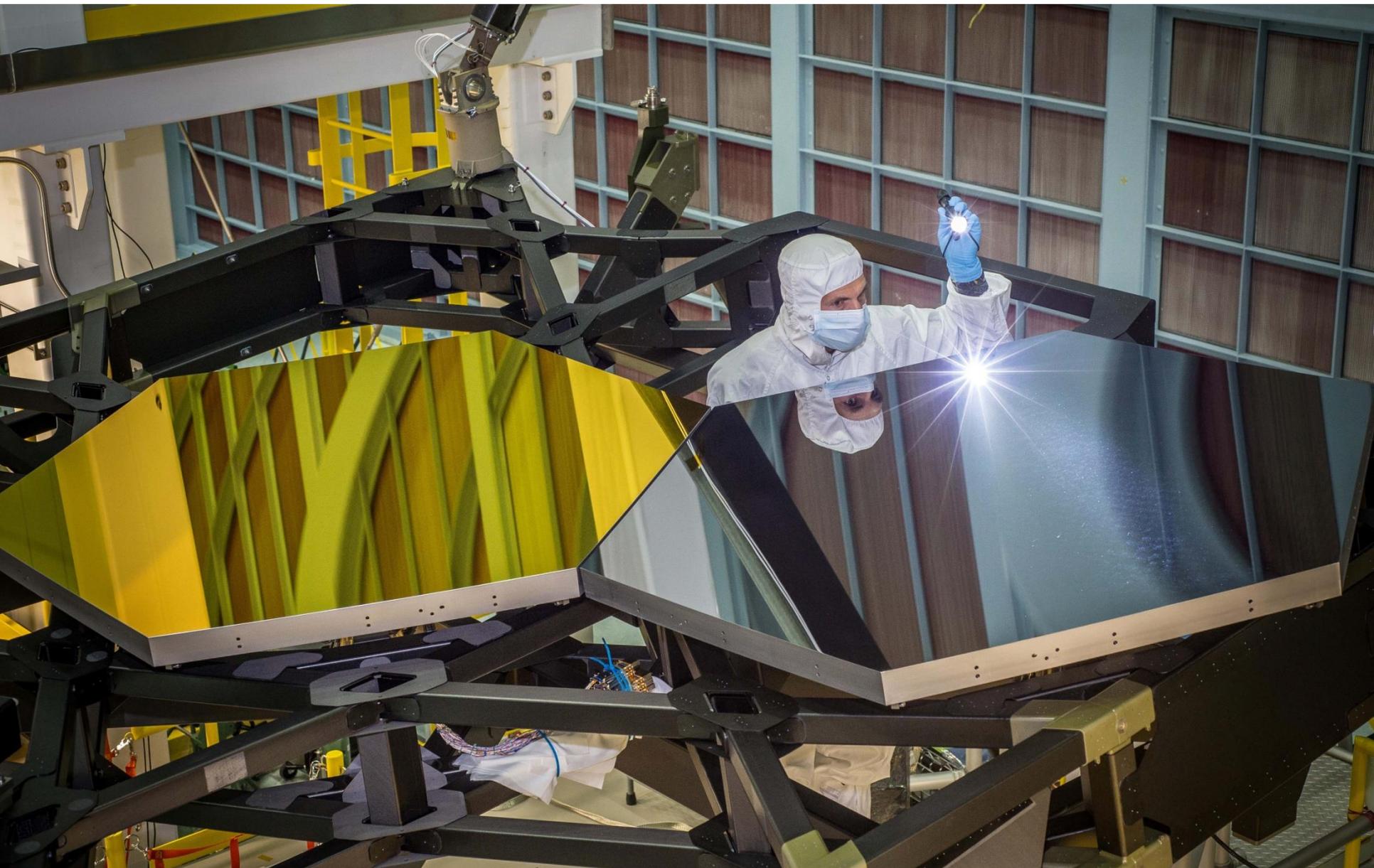


# Pathfinder with Mirrors Installed





# Installed PMSA's



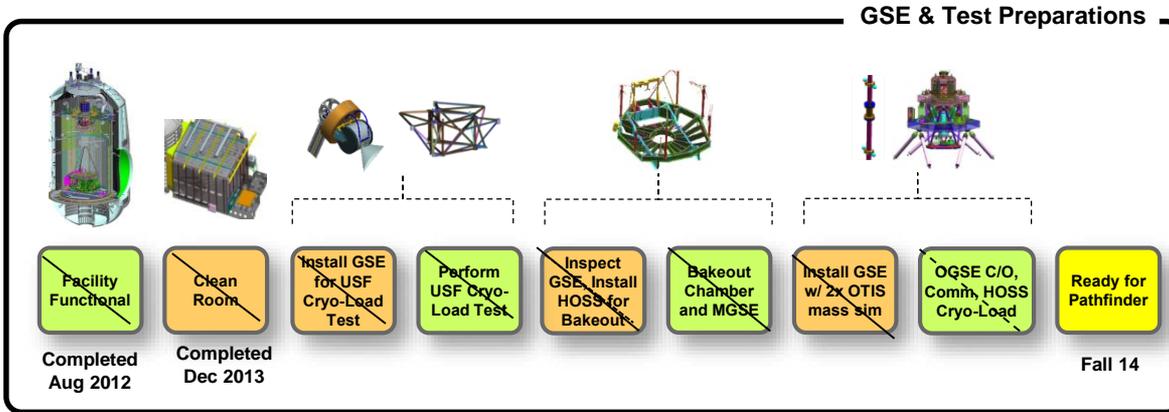


# Pathfinder Deployment





# OTIS Flow

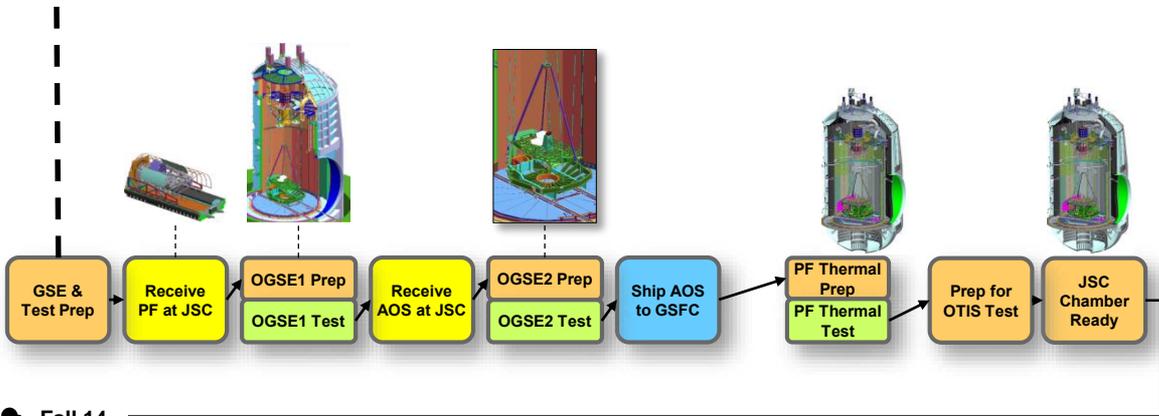


**Acronym**

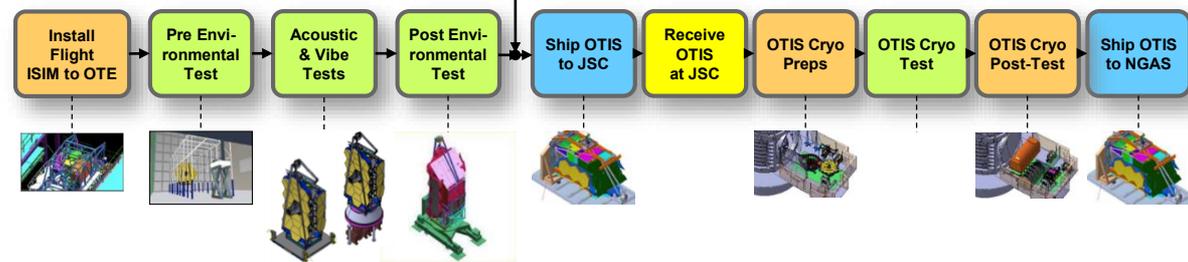
AOS	Aft-Optics Subsystem
GSE	Ground Support Equipment
MGSE	Mechanical Ground Support Equipment
NGAS	Northrop Grumman Aerospace Systems
OGSE	Optical Ground Support Equipment
PF	Pathfinder

**Legend**

Prep & Transport	Functional / Test
Assembly / Integration	Delivery



## Flight OTIS I&T

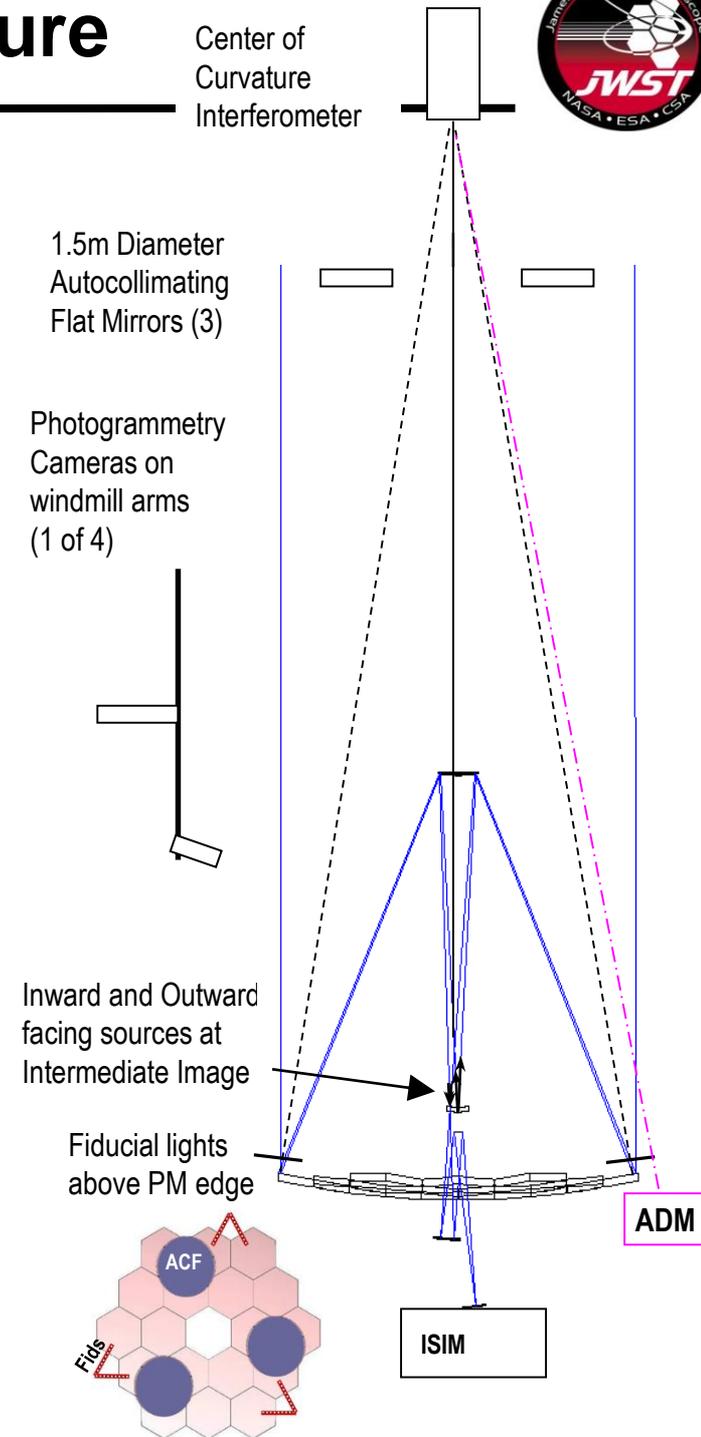




# JSC Optical Test Architecture



- **Integrated Test Assembly supported from top of chamber with vibration isolation**
- **Center of Curvature Interferometer for PM WFE**
  - Absolute Distance Meter (ADM) for axial distance
  - Alignment cameras for initial capture and setup
  - Displacement Measuring Interferometers (DMI) to monitor axial change during thermal distortion test
- **Photogrammetry for position measurements**
- **Inward and Outward Facing Sources at PM-SM intermediate image for imaging to SI's**
  - Direct to SI's "Half Pass"
  - End-to-End "Pass and a Half"
    - Autocollimating Flat Mirrors
- **Fiducial lights around PM for PM pupil alignment tests**





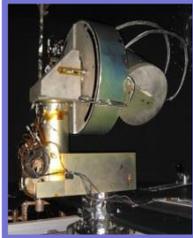
# GSE Tested with Pathfinder



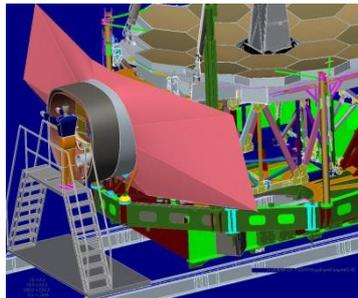
Chamber Isolator Units  
Dynamically isolates OTIS  
Optical Test – 6 units  
delivered to JSC



Cryo Position Metrology (CPM)  
Photogrammetry System  
- First complete system  
in test



ADM  
Updated Model of the ADM to  
the newest generation, CDA  
next month



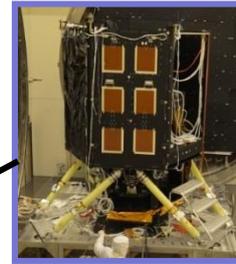
Space Vehicle Thermal Simulator (SVTS)

and Sunshield Simulator

Re-designed to use a GSE cooler and HOSS mounted  
to improve the interfaces  
L5 layer reduced



HOSS – OTIS support structure  
Completed and delivered

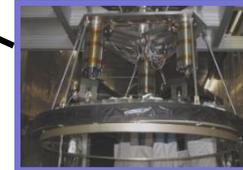


Center of Curvature Optical Assembly (COCO)

- Multiwavelength interferometer (MWIF), null, calibration equipment, coarse/fine PM phasing tools, Displacement Measuring Interferometer – complete, at MSFC



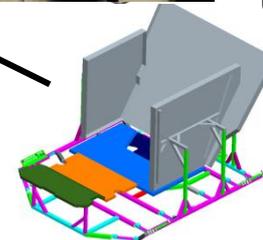
USF Structural Frame – Complete, delivered  
supports Metrology (COCO and 3 ACFs).



3 Auto collimating Flat Mirrors (ACFs)  
1.5 M Plano for Pass and Half Testing  
Last two units in process now.  
1 ACF used in OGSE1+2,  
Other 2 added after OGSE2



AOS Source Plate  
Sources for Pass and Half Test  
Design in progress to support optical  
fiber 72 sources  
Used only in OGSE2



Deep Space Edge Radiation Sink (DSERS)

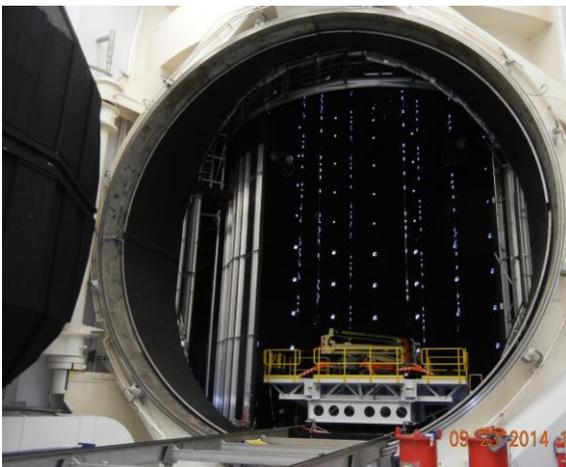
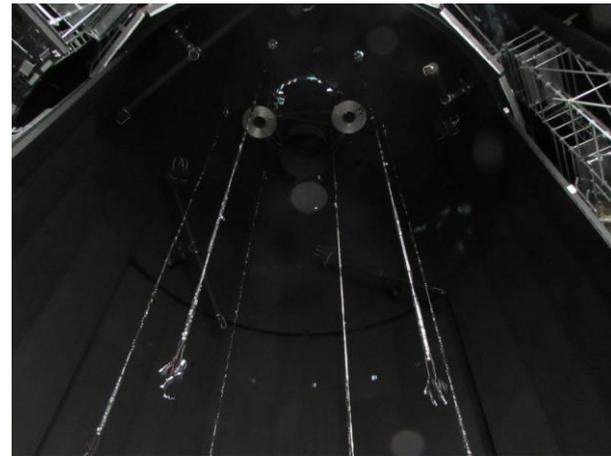
Frame and interfaces are complete and in fabrication,  
the actual DSERS panels will be design/built in 2015

Mag Damper Cryo  
Test Article  
Mag Dampers are  
in fabrication at NGAS



# Commissioning Test

- Commissioning of the test is ongoing right now
- Helium system run with mass simulator for cryo proof
- Cryo optical testing includes cryo photogrammetry, cryo fiber optic throughput, cryo ACF and testing of Center of Curvature Object Assembly (COCOA) pressure tight enclosure

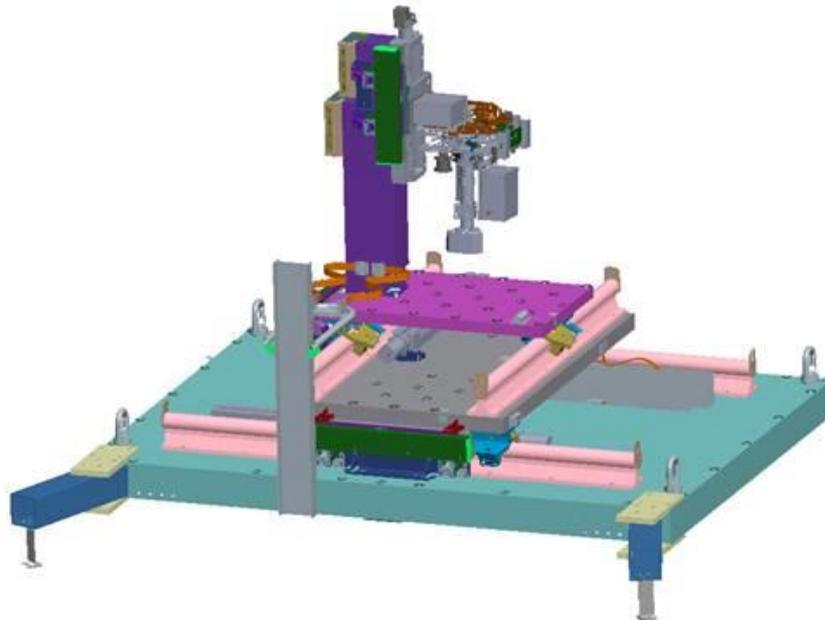




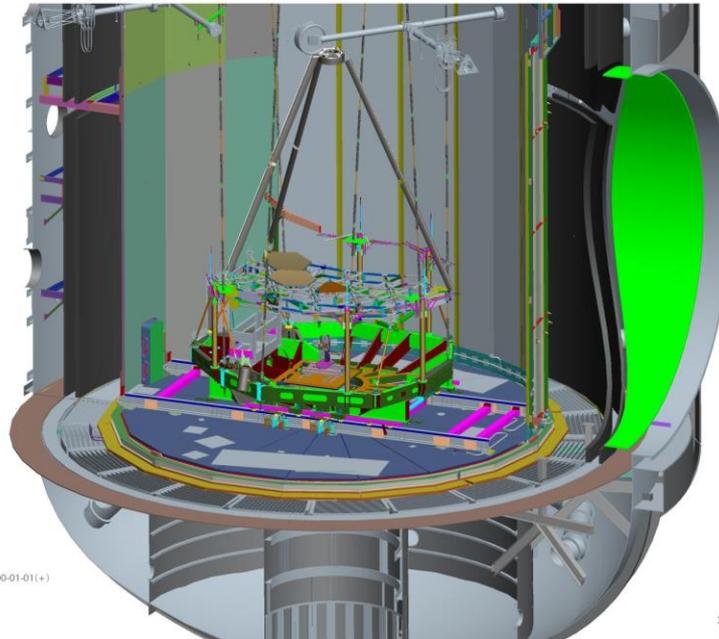
# Beam Image Analyzer (BIA)



- **Beam Image Analyzer (BIA) is a near copy of the successful system use to test the OSIM simulator (detector faces up)**
- **Includes IR camera (HgCdTe), stages, pupil imaging for ASPA checkout with one ACF**
- **Room temperature detector inserted for ambient testing**
- **Will perform cryo calibration of detector location with PG during OGSE1**
- **Used to test ASPA sources during OGSE2 (simulates ISIM)**



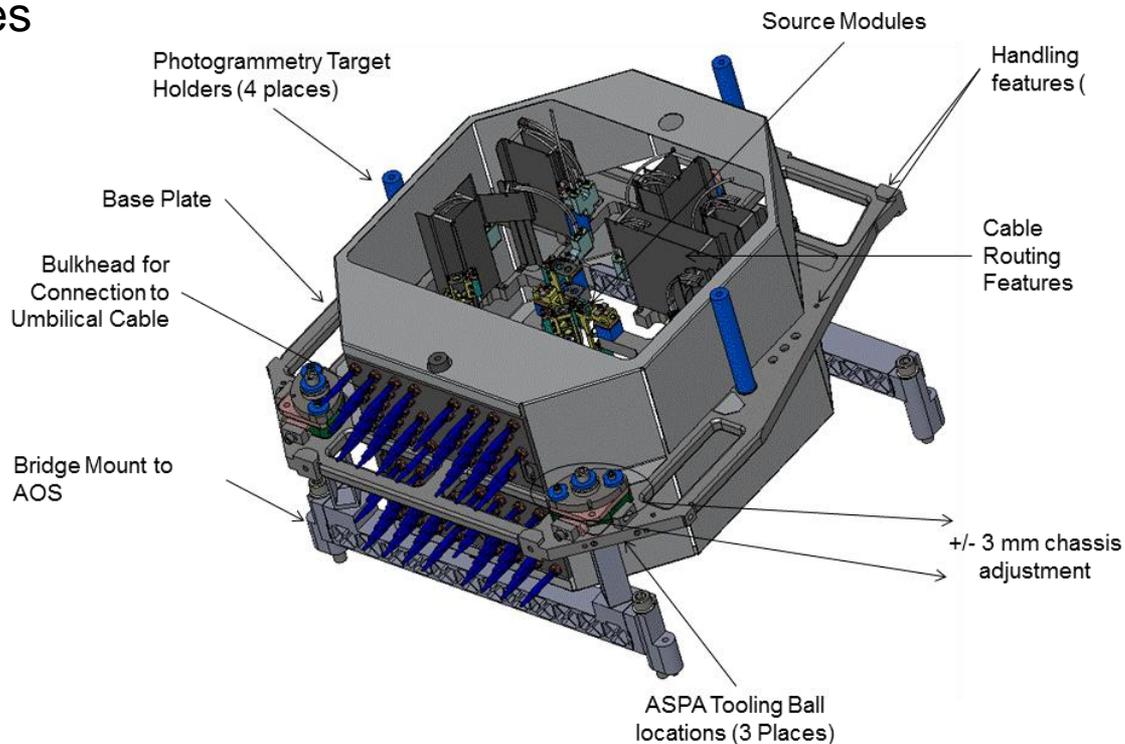
- Checks out key Optical GSE: Center of Curvature Object Assembly (COCOA), Photogrammetry (PG), Hanging Configuration
- Includes mass simulator of AOS to cryo proof the Pathfinder AOS interface (AOS and ASPA are not on for OGSE1)
- Includes Beam Image Analyzer for Calibration with PG
- Piston Sensors used for Thermal Distortion testing w/COCOA
- Allows for dynamics checkout (ambient and cryo) using a combination of optical and accelerometer data



OGSE1

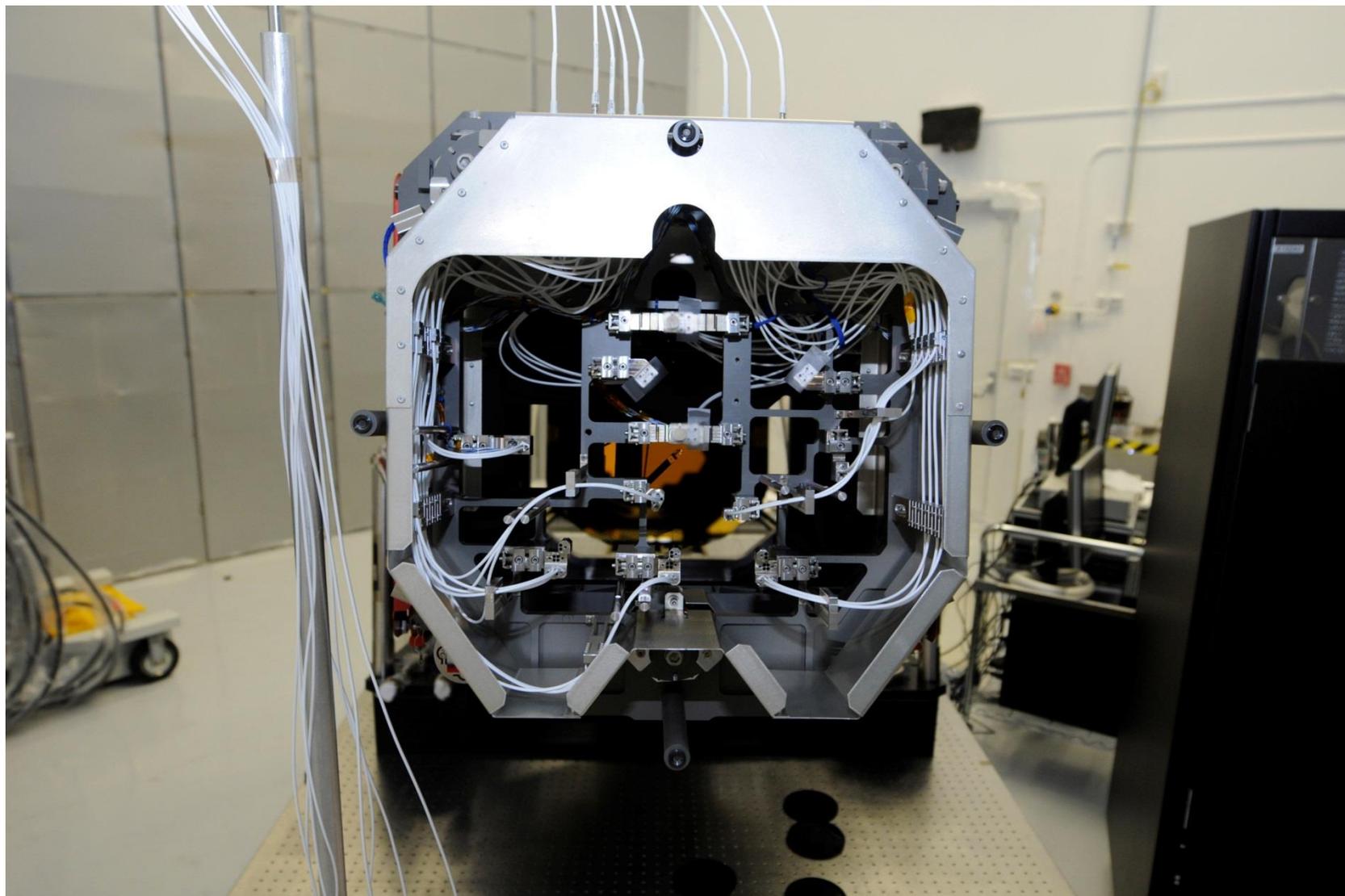
# AOS Source Plate Assembly (ASPA)

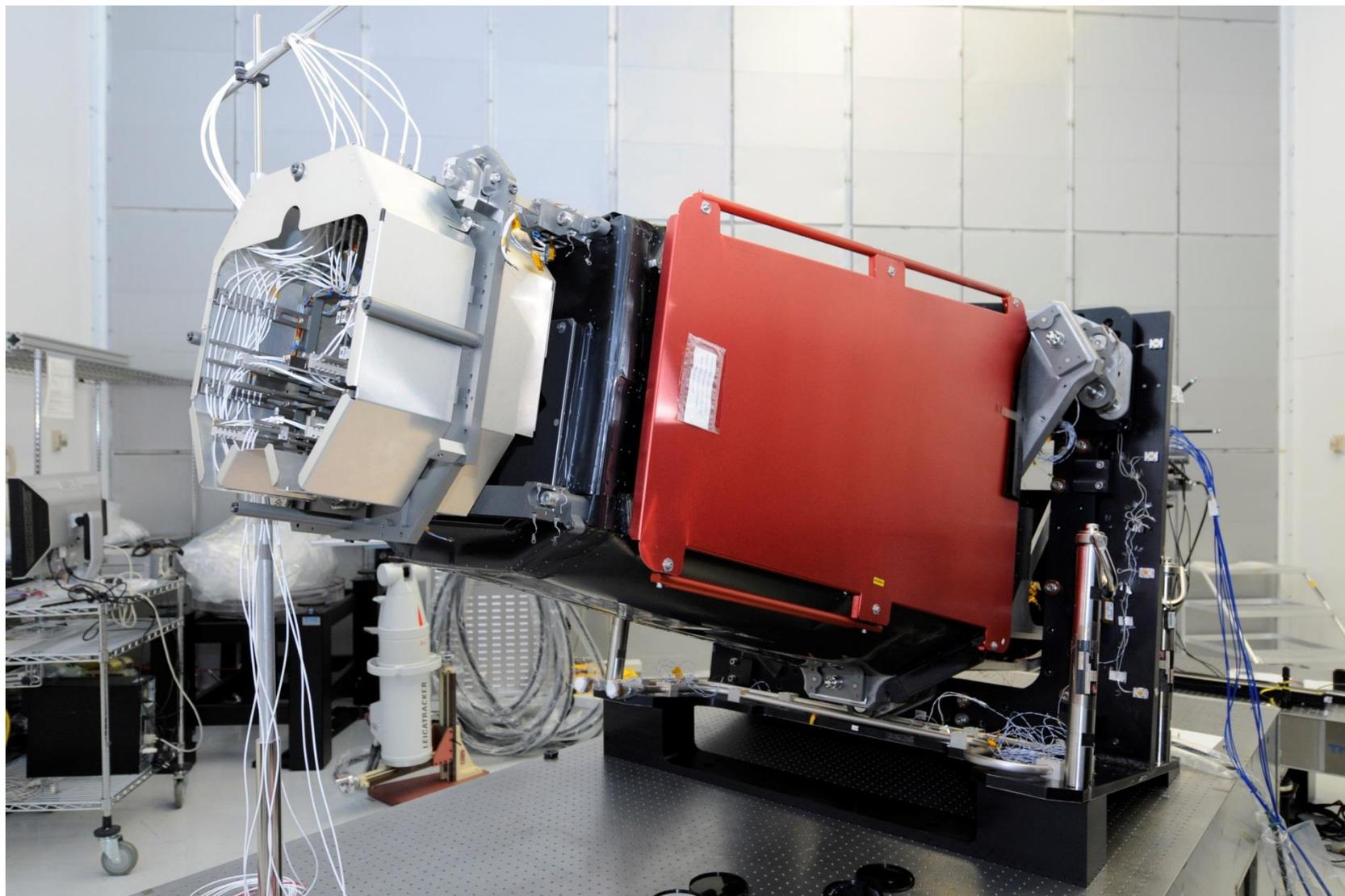
- AOS is installed on Pathfinder at JSC after OGSE1 is complete, ASPA is installed on AOS
- AOS Source Plate Assembly provides downward and upward infrared sources
  - Fiber fed except for MIR sources (uses MEMS MIR sources)
  - Sources can illuminate downward into AOS
  - Sources can illuminate upward to ACF's
  - Except for MIR, sources are supplied by externally accessible light sources



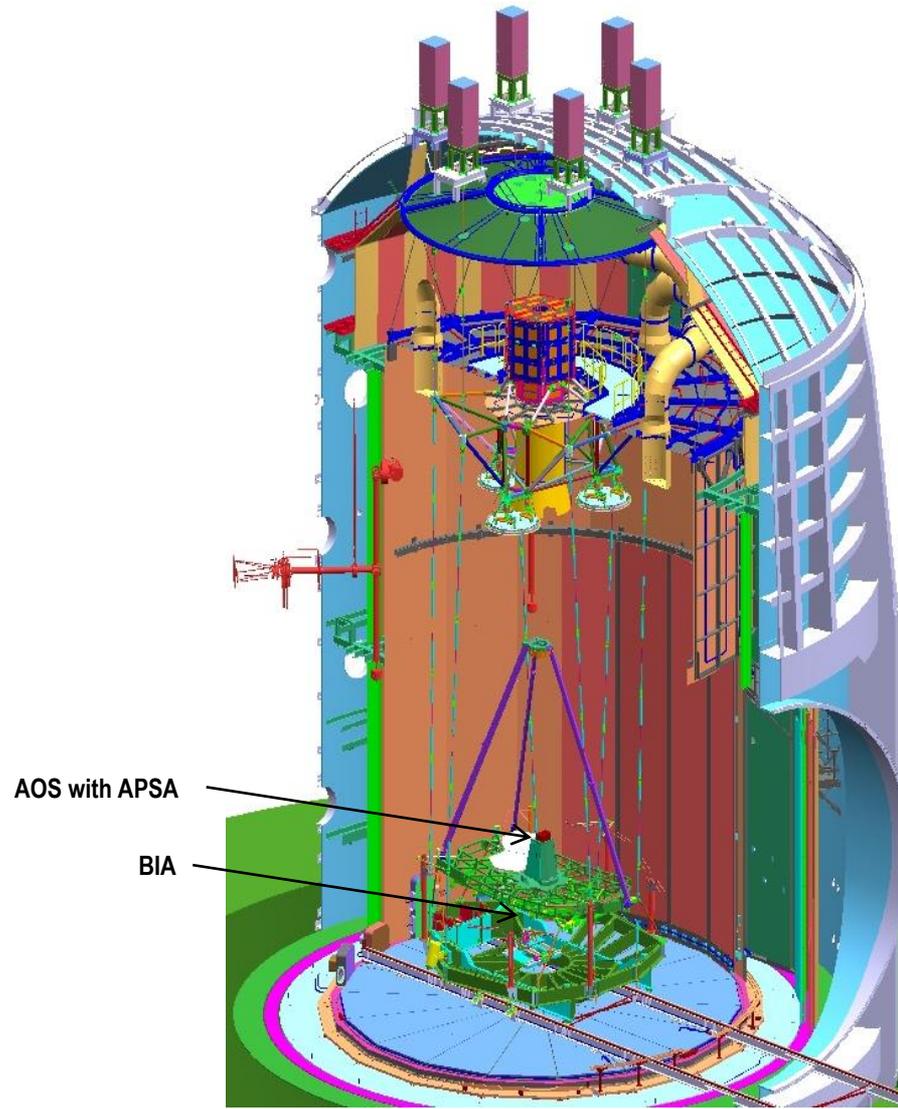


# ASPA End View





- Includes AOS, ASPA, Beam image Analyzer
- First vertical orientation of AOS
- Ambient metrology crosschecks the AOS gravity and crosschecks between photogrammetry and ambient laser trackers
- Will practice OTIS level testing of OTE+ISIM as much as possible
- OGSE2 allows us to check out any issues that came up during OGSE1 that required mitigations



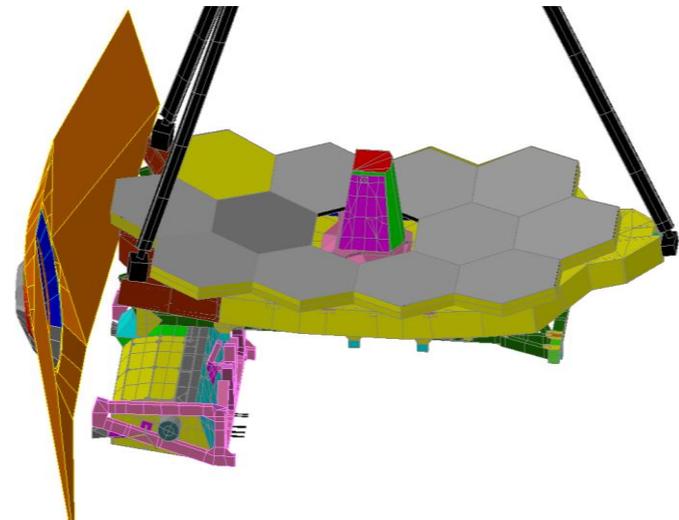
OGSE2

## Objectives:

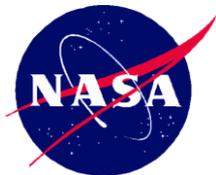
- **Verify safety of OTIS transient timeline**
  - Execute OTIS cooldown and warmup profiles with PMSA sensors
- **Dry run of key OTIS thermal/GSE cooler components**
  - First system checkout of SVTS
  - JSC checkout of GSE Cryocooler for MIRI instrument
- **Thermal Balance of PF with OTIS-like thermal performance – analysis process**
- **Pre-OTIS thermal personnel training**
  - Preparation and In-Test Operation of OTIS-like Thermal Model
  - Thermal Model Correlation with OTIS-like Test Article

## Configuration:

- Pathfinder adds mirror and AOS simulators, MLI closeouts
- SVTS, IEC simulator
- Follows OTIS cooldown and warmup timeline and approaches
- Final 2 ACF's are installed (final test configuration)



**Thermal Pathfinder Configuration**



# Pathfinder Testing



Parameter	Test	Optical Test Equipment	Pathfinder Approach
Radiometric Sensitivity	PM Collection Area	COCOA (reflection area)	With 2 PMSAs
	Vignetting	Pass and a Half	With BIA
	Pupil Alignment / Truant Path	Fiducial lights	With 2 PMSAs & BIA
WFSC	Plate Scale (tilt of single ACF & NIRCcam)	Pass and a Half	With BIA
	WFS&C Demo	Pass and a Half, COCOA, photogrammetry	With 2 PMSAs, SMA & BIA, limited to PMSA and SMA closed loop control
	WFS&C Influence Functions	Pass and a Half, COCOA, photogrammetry	With 2 PMSAs, SMA & BIA
Functional	PMSA Envelope Control Limit	COCOA	Yes
	WF Control Signal Path (PMSA, SMA motion control sign check test)	COCOA	With 2 PMSAs & SMA
	Fine Guidance Loop	Half Pass, Pass and a Half	Partial (no FGS)
Image Quality	PM to AOS alignment	Photogrammetry	With 1 PMSA
	SMA to AOS alignment	Photogrammetry	Yes
	ISIM to AOS alignment	Half Pass, Fiducial Lights	With BIA
	PM RoC	COCOA, ADM	Partial
	low freq PM WFE	COCOA	With 2 PMSAs
	mid frequency PM WFE	COCOA	With 2 PMSAs
	PM conic	COCOA, ADM	With 2 PMSAs
	Ambient PMSA WFE	COCOA	With 2 PMSAs
	Multi-field PSF (single ACF aperture, each SI)	Pass and a Half	With BIA
	SI FOV Survey	Pass and a Half	With BIA
Image Quality Stability	Thermal Distortion: PM WFE & RoC Change (Figure drift of PM over temp change)	COCOA	With 2 PMSAs
	Thermal Distortion: Alignment Change (SMA alignment drift over temp change during warm up from cryo test temp)	Photogrammetry	Yes



# Summary

---



- **The Pathfinder is built and aligned, final sensors are being installed**
  - Will ship to JSC in February
- **Commissioning testing at JSC has begun, the first Pathfinder test begins in Spring 2015**
  - Huge amount of learning both in terms of operations and GSE performance
- **Two optical oriented Pathfinder tests and a thermal Pathfinder test is planned prior to the flight OTIS test**
- **Once Pathfinder testing is complete, we will have done everything feasible to check out the system to be confident the flight OTIS test will go smoothly**